Self-focus and task difficulty effects on cardiovascular reactivity.

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Abstract:

Two experiments examined the joint impact of self-focused attention and task difficulty on performance-related cardiovascular reactivity. Predictions were derived from an application of the principles of motivational intensity theory and its integration with the active coping approach to performance conditions that have consequences for self-esteem. According to this model, self-focus will induce a state of self-evaluation and thus augment the importance of success, and cardiovascular reactivity will increase with difficulty until a task becomes impossible or the goal is not worth the necessary resources. Supporting these predictions, 2 experiments found that high self-focus increased performance-related systolic blood pressure reactivity when difficulty was unfixed (“do your best”) or fixed at a high level. When the task was easy or impossible, however, high self-focus did not affect systolic reactivity relative to low self-focus.

Keywords: cardiovascular reactivity | active coping | self-focus | motivation | self-regulation | psychology | psychophysiology

Article:

A recent series of experiments has shown that performance conditions that have strong consequences for individuals' self-esteem significantly influence cardiovascular reactivity in the context of cognitive challenges. The findings support a recent application of Wright's (1996) integration of motivational intensity theory (e.g., Brehm & Self, 1989) and the active coping approach to cardiovascular activity (Obrist, 1981) to performance conditions that involve the performer's self (Gendolla, 2004). Accordingly, self-relevance makes success important and thus justifies the mobilization of high resources, and cardiovascular reactivity rises proportionally with experienced task difficulty up to the point of maximally justified resources—the level of potential motivation. Evidence stems, for example, from studies on “ego-involving” ability tests (Gendolla & Richter, 2005, 2006a) and explicit (Wright, Dill, Geen, & Anderson, 1998; Wright, Tunstall, Williams, Goodwin, & Harmon-Jones, 1995) or implicit social performance evaluation (Gendolla & Richter, 2006b). However, studies testing the impact of probably the most central variable referring to self-relevance are still missing. This variable is self-awareness, which induces a state of self-evaluation in the individual by focusing attention to the self (Duval & Silvia, 2001; Duval & Wicklund, 1972; Silvia & Duval, 2001a; Wicklund, 1975).

Cardiovascular Response Reflecting Motivational Intensity

According to Wright's (1996) integrative analysis, the impact of the sympathetic nervous system on the heart and the vasculature responds proportionally to subjective task difficulty as long as success is possible and worthwhile. Consequently, cardiovascular reactivity in active coping increases proportionally to the extent of subjective task difficulty until (a) the demand level exceeds persons' abilities (i.e., active coping is too difficult and thus impossible) or (b) the amount of necessary effort for active coping is not justified by the value or the importance of success (for a review, see Wright & Kirby, 2001). Furthermore, (c) the value of success directly determines cardiovascular reactivity when task difficulty is unfixed, that is, when people are asked to “do their best” rather than trying to attain a known and fixed performance standard (e.g., Gendolla & Richter, 2005, 2006b; Wright, Killebrew, & Pimpalapure, 2002; Wright et al., 1995). It follows for settings in which the importance of success is relatively high that cardiovascular reactivity in an unfixed difficulty condition should match the level in a fixed difficult but possible condition. But when the value of success is relatively low, cardiovascular reactivity should be modest under unfixed and fixed conditions, because higher engagement is not justified.

A number of studies have found that especially systolic blood pressure (SBP) responds sensitively to experienced task demand as long as success is possible and worthwhile. In those studies, task demand has been determined by variables like objective task difficulty (Bongard, 1995; Light, 1981; Lovallo et al., 1985; Obrist, 1981; Sherwood, Dolan, & Light, 1990), subjective ability beliefs (Gerin, Litt, Deich, & Pickering, 1995), mood states (Gendolla & Krüsken, 2001, 2002; Silvestrini & Gendolla, 2007), or individual differences in depressiveness (Brinkmann & Gendolla, 2008). Evidence for effects on diastolic blood pressure (e.g., Storey, Wright, & Williams, 1996) and heart rate (Eubanks, Wright, & Williams, 2002; Obrist, 1981) has also been found, but these effects are less consistent. However, although systolic blood pressure responds the most sensitively to task difficulty among these cardiovascular reactivity parameters, systolic blood pressure, diastolic blood pressure, and heart rate can also respond simultaneously in active coping (e.g., Al'Absi et al., 1997; Lovallo et al., 1985).

Self-focus and Cardiovascular Response

As stated above, the effect of self-focused attention on performance-related cardiovascular reactivity is still unclear. All previous studies that dealt with self-focus effects on motivation assessed either achievement (e.g., Liebling & Shaver, 1973; Wicklund & Duval, 1971) or persistence (e.g., Carver, Blaney, & Scheier, 1979; for a review, see Carver & Scheier, 1998) in attempts to mirror motivational intensity or resource mobilization. However, at best those measures could assess this variable only indirectly. Measures of performance-related cardiovascular reactivity have a far higher reliability and validity to assess motivational intensity, according to the evidence discussed above.

Based on the application of the principles of motivational intensity theory to self-relevant performance conditions (Gendolla, 2004), the predictions for the impact of self-focused attention on cardiovascular reactivity are straightforward. According to self-awareness theory (Duval & Wicklund, 1972; Wicklund, 1975), focusing attention to the self induces a state of self-evaluation: The actual state of the self is compared to relevant standards. In achievement situations, this standard is succeeding on a given task. Consequently, self-focused attention should justify relatively high resources, because self-evaluation makes success relatively important—similarly as social evaluation, also self-evaluation has consequences for self-esteem. Preliminary support for this idea was provided by studies showing that self-focused attention increases performance under “do your best” instructions, that is, when task difficulty is unfixed (Liebling & Shaver, 1973; Wicklund & Duval, 1971).

In terms of motivational intensity theory, self-focused attention should lead to a relatively high level of potential motivation. The resulting predictions for cardiovascular reactivity are depicted in Figure 1. When self-focus is high, people are willing to mobilize more resources than when self-focus is low, because success is relatively important. Actual cardiovascular reactivity depends, however, on the combined effect of the level of maximally justified resources and subjective task difficulty. Consequently, reactivity should be low for easy tasks and high for difficult but possible tasks and low for impossible tasks. When task difficulty is unfixed, cardiovascular reactivity should match the level of the highest possible and justified difficulty. When self-focus is low, cardiovascular reactivity should be rather low in general, because the mobilization of higher resources is not justified due to the lower importance of success (potential motivation, respectively) under this condition. It is of note that these predictions are nonintuitive because previous research on self-focused attention and self-regulation has not considered the role of task difficulty for the intensity of motivation.

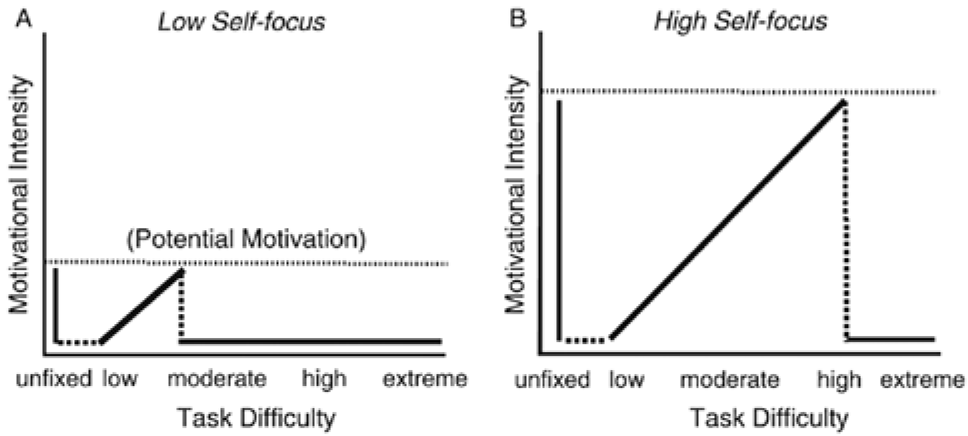

Figure 1. Theoretical predictions of the joint impact of self-focus and task difficulty on motivational intensity and performance-related cardiovascular response. A: Predictions for the condition that self-focus is low. B: Predictions for the condition that self-focus is high.

The Present Experiments

In two studies, participants performed a computer-based letter-detection task with manipulated task difficulty levels. In the high self-focus condition of each experiment, participants were exposed to their face on a video monitor during the task. This is one of the oldest manipulations of self-focused attention (see Duval & Silvia, 2001) that has proven its effectiveness in many experiments (Gendolla, Abele, Andrei, Spurk, & Richter, 2005; Silvia & Duval, 2001b; Silvia & Phillips, 2004). In the low self-focus condition, people were not recorded. The primary measure of interest was SBP reactivity (Wright & Kirby, 2001). To test if past evidence for performance-enhancing effects of self-focus under “do-your-best” instructions (Liebling & Shaver, 1973; Wicklund & Duval, 1971) is compatible with the mobilization of relatively high resources, both studies involved an unfixed difficulty condition. Specifically, Experiment 1 manipulated self-focus and two difficulty conditions: unfixed difficult and a fixed easy level of difficulty. Experiment 2 tested our predictions more comprehensively and administered unfixed, difficult, and extremely difficult tasks under high versus low self-focus. Our theory-based predictions about the joint effect of self-focus and task difficulty on cardiovascular reactivity are depicted in Figure 1.

Data Analysis

In both studies, we used the average of the last two cardiovascular measures taken during the habituation period to create baseline scores (Cronbach's αs >.81) because these two measures did not differ significantly from one another, whereas the other measures did. Reactivity scores were created from the averages of the three cardiovascular measures during task performance

(Cronbach's αs >.86). Preliminary ANOVAs explored if there were gender differences (the distribution of women and men was balanced between the experimental conditions) or baseline differences between the experimental conditions. Moreover, ANCOVAs tested for each cardiovascular parameter if there were reliable associations between baseline and reactivity scores in order to rule out initial value and carryover effects. In the case of significant associations, the reactivity scores were baseline-corrected (cf. Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991). It is of further note that neither participants' answers to questions about smoking, a possible family history of hypertension or cardiovascular disease, nor their body mass index were associated with the cardiovascular baseline and reactivity scores. As in our previous studies (e.g., Gendolla & Richter, 2005, 2006b) and in compliance with the principle to apply the most powerful statistical test for evaluating hypotheses, we used a priori contrasts—the most sensitive statistical tool for the detection of complex interactions (Rosenthal & Rosnow, 1985; Wilkinson & The Task Force on Statistical Inference, 1999)—to test our theory-based predictions about the joint effect of self-focus and task difficult on cardiovascular reactivity (see Figure 1). Given the directed nature of our predictions, we applied one-tailed tests for subsequent focused follow-up cell comparisons.

EXPERIMENT 1

As a first test of our predictions, this study involved two difficulty levels (easy vs. unfixed) and two levels of self-focus (low vs. high). As depicted in Figure 1, we predicted higher reactivity in the self-focus/unfixed cell than in other three conditions.

Method

Participants and Design

Fifty-six university students (32 women and 24 men; mean age 23 years) with various majors (psychology excluded) were randomly assigned to a 2 (self-focus: low vs. high) × 2 (difficulty: unfixed vs. easy) between-persons design and received a small monetary reward corresponding to US$4.

Apparatus and Physiological Measurement

SBP (in mmHg), diastolic blood pressure (DBP; in mmHg), and heart rate (HR; in beats per minute [bpm]) were measured with a computer-aided monitor (Par Physioport III) using oscillometry. A blood pressure cuff (Boso) was placed over the brachial artery above the elbow of the left arm. The cuff automatically inflated in 2-min intervals during two measurement periods: habituation (five measures) and task performance (three measures). All obtained values were stored on computer disk. Experimenter and participants were unaware of all values obtained during the experimental session, which was run with a personal computer.

Procedure

The experimenter was hired and unaware of both the hypotheses and the difficulty condition. After the application of the blood pressure cuff and assessment of biographical data, the experimental session proceeded with a habituation period (10 min) to assess cardiovascular baseline values while participants read an old issue of a magazine. After habituation, participants received instructions for the performance period.

Letter-detection task and difficulty manipulation. The task was a modified version of the d2 letter-cancellation test (Brickenkamp & Zillmer, 1998). Single ds and ps were presented on a computer screen (intertrial interval was 100 ms). Up to two apostrophes appeared above and below each letter. Participants received instructions to press with their right hand a green response key if the letter was a d with exactly two apostrophes. If otherwise, they had to press a red response key. One letter was presented per trial. In the easy condition each letter occurred for 3 s. Participants were informed about this presentation time and had to identify at least 90% of the stimuli correctly within this time frame—a performance standard that was easily attainable according to pretests and a previous experiment (Gendolla & Richter, 2005). In the unfixed difficulty condition participants were instructed to correctly identify as many stimuli as they could—that is “to do their best.” In contrast to the easy condition in which each target was presented for the full 3 s, the letter disappeared after responding in the unfixed condition. Thus, participants in the unfixed condition could work at their own pace. Feedback was given during a training period, but not during the task performance period.

Participants performed 47 training trials with feedback to become familiar with the version of the task they would perform later in the critical performance period. No feedback was given during the performance period.

Self-focus manipulation. Following the task instructions, participants read that one ostensible purpose of the experiment was to measure face activity during task performance. For half the participants (high-self-focus condition) the experimenter adjusted a video camera to the participants' face profile. On a TV monitor—placed next to the computer screen—the participants could see the picture of their face that the camera was recording. The other half of the participants (low-self-focus condition) were told that the camera was out of order. Whereas participants in the self-focus condition saw their face profile on the TV monitor, participants in the low-self-focus condition saw only the monitor's backside.

After the manipulations, participants performed the practice sequence of the letter cancellation task. Then, participants in the easy condition rated task difficulty (“How difficult does the task appear to you?”) on a scale ranging from very easy (1) to very difficult (9). As in past research (e.g., Gendolla & Richter, 2005, 2006b; Wright et al., 2002, 1995), participants in the unfixed difficulty condition did not rate task difficulty to prevent commitment to a self-chosen performance standard that would turn the unfixed condition into a “quasi-fixed” one (e.g., Gendolla, Abele, & Krüsken, 2001). Once instructed, participants performed the letter cancellation task for 5 min. Finally, participants were probed for suspicion, debriefed, and given their payment.

Results

Preliminary Analyses

Preliminary 2 (self-focus) × 2 (difficulty) × 2 (gender) ANOVAs on the cardiovascular baselines found a gender main effect on the SBP and DBP baselines (both $ps<.04$), which were higher for men ($M=120.83$, $SE=2.18$ for SBP; $M=76.82$, $SE=1.41$ for DBP) than for women ($M=111.81$, $SE=1.17$ for SBP; $M=73.07$, $SE=1.10$ for DBP). This is a common physiological finding (Wolf et al., 1997). Additionally, there was a significant gender effect on DBP reactivity, which will be reported below.

Difficulty Ratings

A one-sample t test found that participants' difficulty ratings in the easy condition ($M=2.07$, $SE=0.20$) were significantly lower than 5, which was the scale's midpoint, $t(27)=14.74$, $p<.001$. This reflects the successful manipulation of an easy task.

Cardiovascular Baselines

Because the baseline scores of the last two measures of DBP showed only low internal consistency (Cronbach's $\alpha=.47$), we used only the last DBP habituation measure as the baseline value. Two (self-focus) × 2 (difficulty) between-persons ANOVAs of the baseline measures of

HR, SBP, and DBP revealed no differences between the four conditions (all ps>.24). Means and standard errors appear in Table 1.

Table 1. Cell Means and Standard Errors of the Cardiovascular Baseline Values in Experiment 1

Difficulty	**Mean**		**Standard error**	
	Low self-focus	**High self-focus**	**Low self-focus**	**High self-focus**
SBP				
Easy	116.87	113.96	3.33	2.51
Unfixed	116.89	114.98	2.56	1.90
DBP				
Easy	73.86	73.21	1.70	2.24
Unfixed	75.02	76.62	1.81	1.41
HR				
Easy	74.06	74.43	1.66	1.39
Unfixed	74.89	74.50	1.63	1.63

Notes. *n*=14 in each cell. SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate. SBP and DBP are in mmHg, HR is in beats/min.

Cardiovascular Reactivity

Preliminary ANCOVAs found a significant association between baseline and reactivity scores for DBP, $F(1,51)=28.07$, $p<.001$, $r=-.61$, but not for SBP and HR (ps>.30). Consequently, we adjusted only the DBP reactivity scores with respect to the baseline.

SBP reactivity. The a priori contrast was highly significant, $F(1,52)=11.44$, $p<.001$, $MSE=35.86$. A nonsignificant effect for the residual ($F<1$) indicated that the contrast captured all significant variance. The systolic reactivity pattern, displayed in Figure 2, occurred exactly as anticipated: SBP reactivity in the high-self-focus/unfixed condition (M=10.95, SE=2.01) was significantly stronger than in the remaining three cells, all ts(52)>1.88, ps<.04: high-self-focus/easy (M=3.67, SE=1.66), low-self-focus/easy (M=4.00, SE=1.32), low-self-focus/unfixed (M=6.44, SE=1.30). No other cell differences approached significance (all ps>.20). This confirms the predicted 3:1 pattern of SBP reactivity.

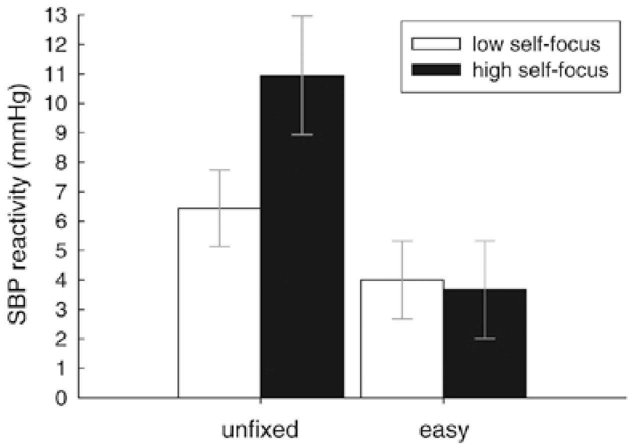

Figure 2. Cell means and standard errors of the mean of systolic blood pressure (SBP) reactivity during task performance in Experiment 1.

DBP and HR reactivity. For diastolic reactivity, neither the a priori contrast nor the test of the residual was significant (both Fs<1). Cell means were as follows: high-self-focus/easy (M=4.52, SE=2.30), low-self-focus/easy (M=2.78, SE=2.27), high-self-focus/unfixed (M=4.85, SE=2.32), and low-self-focus/unfixed condition (M=4.73, SE=2.26).1 The a priori contrast for HR reactivity only approached significance, F(1,52)=2.67, p=.10, MSE=54.54, (residual F<1.30), and HR reactivity roughly resembled the predicted 3:1 pattern: high-self-focus/unfixed (M=6.48, SE=2.85), high-self-focus/easy (M=0.48, SE=1.20), low-self-focus/unfixed (M=4.96, SE=2.09), low-self-focus/easy (M=2.82, SE=1.30).

Task Performance

We excluded all trials with response times below 100 ms (0.01% of all responses) to minimize responses made by chance. As presented in Table 2, the number of performed letters differed largely between the unfixed and the easy conditions, as confirmed by a difficulty main effect in a 2 (self-focus) × 2 (task difficulty) ANOVA, F(1,52)=671.67, p<.001, in the absence of other effects (ps>.50). Consequently, we focused on the percentage of errors by dividing the number of errors by the total number of identified letters (and multiplying the result by 100) instead of the mere number of correctly identified letters. A preliminary ANCOVA revealed a highly significant association between the percentage of errors committed during in the performance period with the number of errors committed during the practice trials, $F(1,51)=12.55$, $p<.001$, $r=.49$. Therefore we analyzed covariance-adjusted error percentages. A conventional 2 (self-focus) × 2 (task difficulty) ANOVA of this performance index revealed a significant main effect of task difficulty, $F(1,51)=11.99$, $p<.001$, reflecting more errors in the unfixed than in the easy condition (Ms=1.10% vs. 0.41%), which was qualified by a marginally significant interaction, $F(1,51)=3.14$, $p<.08$. Given that a previous study with this type of task has revealed performance effects that corresponded to those of systolic reactivity during task performance (Gendolla & Richter, 2005), we directly tested with a focused contrast if performance in the high-self-focus/unfixed cell was better than in its low-self-focus counterpart—which was the case, $t(51)=1.62$, $p=.05$. Simultaneously, self-focus had no impact on performance in the easy condition ($p>.37$).2

Table 2. Cell Means and Standard Errors of Task Performance in Experiment 1

Difficulty	**Mean**		**Standard error**	
	Low self-focus	**High self-focus**	**Low self-focus**	**High self-focus**
Total				
Unfixed	307.00	308.21	13.25	9.74
Easy[a]	94.43	94.36	0.39	0.45
Errors[b]				
Unfixed	4.07	2.77	0.53	0.53
Easy	0.23	0.50	0.53	0.53
Errors (%)[b]				
Unfixed	1.32	0.87	0.20	0.20
Easy	0.28	0.53	0.20	0.20

Notes. *n*=14 in each cell. Total: total number of identified letters, Errors: total number of errors, Errors (%): number of errors/total number of identified letters × 100.

a The small differences in the total number of identified letters are due to the few eliminated reactions that were made faster than 100 ms.

b [b] Covariate-adjusted with respect to the number of errors committed during the practice trials.

Correlation Analysis

An examination of the correlations between cardiovascular reactivity and the performance variables revealed only a positive association between SBP reactivity during task performance and the number of performed stimuli, $r=.33$, $p<.01$. However, considering the number of performed stimuli as covariate in the a priori contrast for systolic reactivity revealed no significant covariate effect ($p>.43$). Consequently, SBP reactivity cannot be explained by mere physical effort due to the key-press rate.

Discussion

As predicted, self-focused attention led to stronger SBP reactivity during task performance when task difficulty was unfixed, but it had no effect when the task was easy and did not require high engagement. The resulting 3 versus 1 pattern of SBP reactivity—our primary measure of interest—fits the predictions made by the application of motivational intensity theory (Brehm & Self, 1989; Wright, 1996) to task performance under self-awareness as a setting that involves the performer's self (Gendolla, 2004). Moreover, this study shows, for the first time to our knowledge, that self-focus does not influence motivation and performance when people can easily perform a task.

Reactivity of DBP did not describe the predicted pattern of SBP; HR roughly, though not significantly, corresponded with systolic reactivity. This dissociation of reactivity effects is not surprising for physiological reasons (Brownley, Hurwitz, & Schneidermann, 2000; Papillo & Shapiro, 1990). Systolic blood pressure is systematically influenced by myocardial contractility that is potentiated by β-adrenergic sympathetic discharge, whereas diastolic blood pressure mainly depends on vascular resistance, which is unsystematically affected by sympathetic arousal. Heart rate is determined by both sympathetic and parasympathetic arousal and should thus only respond to resource mobilization when the sympathetic impact is stronger—which is not always the case (Berntson, Cacioppo, & Quigley, 1993; Obrist, 1981).

Another noteworthy point—although not the focus of the present analysis of cardiovascular reactivity—is that this study found achievement effects corresponding to systolic reactivity. Participants in the high-self-focus/unfixed condition committed fewer errors than people in the low-self-focus/unfixed condition. This suggests that in the unfixed difficulty condition self-focus boosted motivational intensity and enhanced performance, which replicates the classic achievement-enhancing effects of self-focus under unfixed “do your best” conditions (Liebling & Shaver, 1973; Wicklund & Duval, 1971). Simultaneously, the number of errors did not differ between the easy conditions, where SBP reactivity was modest regardless of the self-focus manipulation.

EXPERIMENT 2

To replicate and extend the findings of the first study, this experiment administered conditions of unfixed difficulty and fixed high and extremely high difficulty under low versus high self-focus. As outlined in the introduction and depicted in Figure 1, we anticipated that high self-focus induces a state of self-evaluation and thus justifies the mobilization of high resources as long as success is possible. Consequently, cardiovascular reactivity should be relatively high in both the unfixed and the fixed difficult cells. In the extremely difficult condition, where participants had no control over the outcome, reactivity should be modest due to disengagement. In the low-self-focus condition we expected relatively low cardiovascular reactivity in all three difficulty conditions, because higher engagement was not justified due to the lower importance of success (no self-evaluation).

Method

Participants and Design

Sixty university students (27 women, 33 men; mean age 23 years) with different majors (psychology excluded) voluntarily participated and received a small monetary reward corresponding to US$4. Respondents were randomly assigned to the conditions of a 2 (self-focus: low vs. high) × 3 (task difficulty: unfixed vs. difficult vs. extremely difficult) between-persons design.

Apparatus and Procedure

Experimental procedure, blood pressure/HR monitor, measurement intervals, administered type of task, and the self-focus manipulation were identical with Experiment 1. Also the unfixed difficulty condition of the letter detection task was the same as in the first study. In both fixed difficulty conditions participants received instructions to identify at least 90% of the stimuli correctly, as in the easy condition of the previous study. However, now it was difficult to attain this performance standard in the fixed difficult condition, where the letters were presented for 600 ms (i.e., 295 trials in 5 min). Success was impossible in the fixed extremely difficult condition, where stimuli were presented for only 350 ms (i.e., 397 trials in 5 min.) and where performance above chance level was not possible (according to pretests). Participants had to respond during the stimulus presentation times.

Immediately before starting to perform, participants in the two fixed difficulty conditions rated again task difficulty (very easy [1] to very difficult [9]). As an extension of Experiment 1, participants completed a translation (Heinemann, 1979) of the private-self-consciousness scale (Fenigstein, Scheier, & Buss, 1975) after task performance to assess the effectiveness of the self-focus manipulation. This scale reacts sensitively to manipulated self-focus states (e.g., Silvia & Eichstaedt, 2004; Wood, Saltzberg, & Goldsamt, 1990). The measure was administered at this point—when participants were still exposed to their face profile or the backside of the TV monitor—in order to prevent too much distraction from the task instructions prior to performance. Participants rated the items (e.g., I reflect about myself a lot) on scales from (1) strongly disagree to (7) strongly agree. Finally, participants were probed for suspicion, debriefed, and given their payment.

Results

Preliminary Analyses

As the only significant gender effects, preliminary 2 (self-focus) × 3 (task difficulty) × 2 (gender) ANOVAs found again a main effect on the SBP baseline values, $F(1,48)=8.90$, $p<.004$, and HR, $F(1,48)=3.81$, $p<.06$, indicating higher values for men (SBP: $M=114.39$, $SE=2.01$; HR: $M=77.10$, $SE=1.67$) than for women (SBP: $M=106.28$, $SE=1.81$; HR: $M=72.71$, $SE=1.50$). No gender effect on cardiovascular reactivity approached significance.

Verbal Manipulation Checks

A 2 (self-focus) × 2 (task difficulty) ANOVA of the difficulty ratings in the fixed difficulty conditions found only the intended difficulty main effect, $F(1,36)=8.09$, $p<.007$, due to higher ratings in the extreme condition ($M=7.80$, $SE=0.24$) than in the difficult condition ($M=6.50$, $SE=0.39$). A reliability analysis of the private self-consciousness scores found that two items correlated modestly or negatively with the rest of the scale. Thus, we created self-consciousness scores after eliminating these two items (Cronbach's $\alpha=.73$). A 2 (self-focus) × 3 (task difficulty) ANOVA of these scores revealed only a main effect of the self-focus manipulation, $F(1,54)=5.62$, $p<.02$, reflecting higher scores in the high-self-focus condition ($M=3.66$, $SE=0.17$)

than in the low-self-focus condition (M=3.15, SE=0.13). It is of note that an ANOVA of the self-consciousness scale scores before the item reduction also revealed only a significant self-focus main effect ($p<.004$).

Cardiovascular Baselines

Two (self-focus) × 3 (task difficulty) ANOVAs found no differences between the conditions for any baseline index. Cell means and standard errors appear in Table 3.

Table 3. Cell Means and Standard Errors of the Cardiovascular Baseline Values in Experiment 2

Difficulty	**Mean**		**Standard error**	
	Low self-focus	**High self-focus**	**Low self-focus**	**High self-focus**
SBP				
Unfixed	115.10	109.50	2.57	2.56
Difficult	108.70	107.50	3.78	3.46
Extreme	107.40	113.85	2.55	4.99
DBP				
Unfixed	71.30	70.80	2.42	1.87
Difficult	69.55	69.50	1.46	1.89
Extreme	71.35	68.00	1.71	2.72
HR				
Unfixed	77.50	75.35	4.18	1.89
Difficult	72.25	72.80	0.96	1.50
Extreme	74.10	78.90	1.25	4.27

Notes. $n=10$ in each cell. SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate. SBP and DBP are in mmHg, HR is in beats/min.

Cardiovascular Reactivity

The a priori contrast weights for the reactivity scores were assigned in accordance with the predictions. We anticipated modest reactivity in all low-self-focus conditions and the high-self-focus/extremely difficult cell (contrast weights −1) but relatively high reactivity in both the high-self-focus/unfixed and the high-self-focus/difficult conditions (contrast weights+2). Preliminary ANCOVAs found only a significant associations between the SBP baseline values and reactivity scores, $F(1,53)=6.39$, $p<.02$, $r=-.36$ (other ps>50).

SBP reactivity. As expected, the a priori contrast of the baseline-adjusted reactivity scores was highly significant, $F(1,53)=15.42$, $p<.001$, $MSE=50.97$; the residual was not ($F<1.21$). Thus, the contrast captured all significant variance. As depicted in Figure 3, the pattern of cell means resembled our effort-related predictions, which were further supported by focused cell contrasts. Systolic reactivity in both the high-self-focus/unfixed ($M=12.96$, $SE=2.26$) and the high-self-focus/difficult ($M=17.74$, $SE=2.27$) cells was as anticipated significantly higher than in their low-self-focus counterparts (low-self-focus/unfixed: $M=6.58$, $SE=2.30$; low-self-focus/difficult: $M=7.63$, $SE=2.26$), both $ts(53)>1.97$, $ps<.03$. The difference between the high-self-focus/unfixed and the high-self-focus/difficult conditions was, as expected, not reliable ($p>.14$). Furthermore, SBP reactivity in the high-self-focus/extreme cell ($M=8.64$, $SE=2.28$) was significantly lower than in the high-self-focus/difficult condition, $t(53)=2.81$, $p<.01$, and marginally significantly lower than in the high-self-focus/unfixed cell, $t(53)=1.34$, $p<.09$. No differences emerged between the high-self-focus/extreme and the low-self-focus/extreme ($M=7.55$, $SE=2.27$) cells in which SBP reactivity was, as anticipated, relatively low. The three low-self-focus conditions also did not differ from one another (all $ps>.50$).

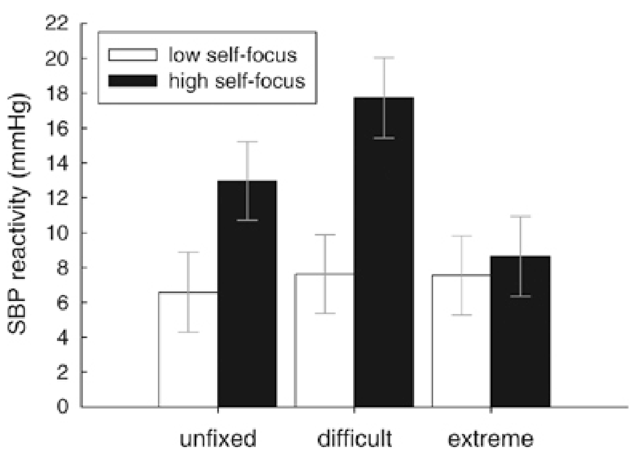

Figure 3. Cell means and standard errors of the mean of systolic blood pressure (SBP) reactivity during task performance in Experiment 2.

DBP and HR reactivity. Cell means appear in Table 4. For both measures, neither the a priori contrasts (ps>.34) nor the residuals (Fs<1.24) approached significance.

Table 4. Cell Means and Standard Errors of the Reactivity Scores of DBP and HR in Experiment 2

Difficulty	**Mean**		**Standard error**	
	Low self-focus	**High self-focus**	**Low self-focus**	**High self-focus**
DBP				
Unfixed	6.33	9.65	1.36	2.17
Difficult	9.25	11.20	2.20	2.46
Extreme	7.45	11.85	1.05	2.60
HR				
Unfixed	5.10	1.90	2.40	2.85
Difficult	2.48	6.07	1.11	3.05
Extreme	1.70	4.82	1.28	2.83

Notes.n=10 in each cell. DBP: diastolic blood pressure, HR: heart rate. DBP is in mmHg, HR is in beats/min.

Task Performance

We excluded again trials with response times lower than 100 ms (3% of all responses). The number of performed letters differed largely between all three difficulty conditions, according to a significant task difficulty main effect in a 2 (self-focus) × 3 (task difficulty) ANOVA, F(2,54)=105.07, p<.001. All three difficulty conditions differed significantly from one another (all ps<.05): unfixed (M=279.60, SE=7.02), difficult (M=294.25, SE=0.46), extreme (M=376.15, SE=4.97). No other effect was significant (ps>.50). Unlike Experiment 1, there were no significant associations between the numbers of errors committed during the task practice and performance trials (p>.50). Therefore we did not consider the practice trials errors as a covariate. On the percentage of errors, the difficulty effect was reliable, F(1,54)=349.52, p<.001: Unfixed

($M=3.03$, $SE=0.64$), difficult ($M=34.12$, $SE=2.37$), extreme ($M=75.62$, $SE=2.27$), and focused comparisons found that all three difficulty conditions differed reliably from one another ($ps<.001$). The self-focus manipulation had no effects within the difficulty conditions ($ps>.20$).[3]

Correlation Analysis

Regarding correlations between the cardiovascular reactivity measures and the task performance variables, there was only a negative correlation between SBP reactivity and the number of performed stimuli, $r=-.25$, $p=.05$. Moreover, the number of performed stimuli was not significantly related to systolic reactivity when it was considered as a covariate in the a priori contrast ($p>.50$).

Discussion

As predicted, high self-focus led to increased systolic reactivity in the unfixed difficulty condition, replicating the results of Experiment 1, and in the difficult condition, but not in the extremely difficult condition, in which participants had learned that correct letter identification was not possible above chance level. This made active coping impossible and thus should have reduced sympathetic discharge to the heart (Obrist, 1981; Wright, 1996), resulting in modest SBP reactivity. These effects describe the anticipated interaction between self-focus and task difficulty on performance-related cardiovascular reactivity (Figure 1)—this time with a significant effect on the self-focus manipulation check. As in Experiment 1 and several other studies (for reviews, see Gendolla, 2004; Wright, 1996; Wright & Kirby, 2001), effects on HR and DBP were not significant, which is, however, not surprising given the physiological processes outlined earlier.

In contrast to Experiment 1, the present study did not find that self-focus affected the performance measures, suggesting a dissociation of motivational intensity and achievement. However, as noted earlier, the relationship between resource mobilization and achievement is complex. One reason for the dissociation of effort and performance in Experiment 2 could be the relatively extreme manipulation of task difficulty.

General Discussion

Our studies supported the predictions: The effects of self-focus on performance-related cardiovascular response depended on task difficulty when the demand level was fixed. More specifically, high self-focus increased performance-related SBP reactivity when the task was difficult (Experiment 2), but not when the task was easy (Experiment 1) or when the task was so extremely difficult that active coping was no longer possible (Experiment 2). That is, performance-related cardiovascular reactivity was jointly determined by self-focus and task difficulty rather than by self-awareness alone. The observed pattern of systolic reactivity supports the idea that self-focus justifies the mobilization of the high resources, which are necessary for difficult tasks. Nevertheless only low resources are mobilized when the task is easy or success is impossible. In addition, both of the present studies found that self-focus enhanced systolic reactivity when task difficulty was unfixed and participants followed “do-your-best” instructions. This finding corresponds to seminal research on the motivational effects of self-focus (Liebling & Shaver, 1973; Wicklund & Duval, 1971)—this time with a direct measure of motivational intensity—and also replicates the effects of other variables referring to self-relevance, like social evaluation (Wright et al., 1995, 2002) and ability tests (Gendolla & Richter, 2005, 2006b) on performance-related cardiovascular reactivity. Moreover, the present effects of unfixed task difficulty (“do your best”) correspond to those of unclear task difficulty—that is, when individuals have no information about work load or performance standards (Richter & Gendolla, 2006, 2007).

Regarding alternative explanations for our findings, one could suppose that the self-focus manipulation had distracted participants rather than influencing the importance of success. According to the Self-Regulatory Executive Function (S-REF) model (Wells & Matthews, 1996), for instance, focusing attention to the self reduces the amount of attention that can be allocated to the external world and the performance of attention-sensitive tasks—like the here-administered letter detection task. However, a distraction process cannot explain the pattern of cardiovascular reactivity that was predicted and found in the present experiments. If the self-focus manipulation would have had an attention absorbing effect, the consequence should have been higher levels of effective task difficulty on each of the manipulated levels. Effects on cardiovascular response then should have mirrored those demonstrated in numerous studies on ability differences (see Wright & Kirby, 2001) or mood manipulations (see Gendolla & Brinkmann, 2005). More specifically, in the easy condition of Study 1, systolic reactivity should have been higher in the self-focus condition than in the no-self-focus condition, because effective difficulty should have been higher in the former condition. This was not case—as we have predicted according to our elaboration of the principles of motivational intensity theory, these conditions did not differ. Moreover, in the difficult condition of Study 2, reactivity should have been lower in the high-self-focus condition compared to the low-self-focus condition, because effective difficulty in the former condition should have been too high, resulting in disengagement; effective difficulty in the latter condition should have been high but still possible (e.g., Gendolla & Krüsken, 2001; Wright, Wadley, Pharr, & Butler, 1994). Also this was not the case. In fact, as predicted, the opposite effect occurred. This makes it most implausible that cardiovascular reactivity was the result of an attention capacity reducing effect of the self-focus manipulation.

A still further argument against this “distraction hypothesis” can be found in the performance data, which should mirror reductions in attention (see Wells & Matthews, 1996). But in Experiment 1 the number of committed errors in the letter detection task described the same pattern as systolic reactivity without any evidence for less accurate performance in the self-focus condition. In Experiment 2, the self-focus manipulation had no significant effect on the performance indices; only the task difficulty manipulation had main effects. Moreover, cardiovascular reactivity was also statistically independent from the key press rate. Consequently, the present findings are also not attributable to the mere mobilization of physical effort. Rather, the reported patterns of cardiovascular reactivity are in accordance with the idea that self-focus justified the mobilization of relatively high resources, because it made success relatively important by eliciting a state of self-evaluation, as suggested by self-awareness theory (Duval & Wicklund, 1972; Wicklund & Duval, 1971). Thus, we interpret the present findings as additional support for the idea that high self-relevance justifies the mobilization of high resources and that motivational intensity is proportional to task difficulty up to the level of maximally justified resources—that differed between the high and low self-focus conditions—as long as success is possible (Gendolla, 2004). However, we acknowledge that future research could include manipulations that have less potential to raise the issue of a confounding between the self-focus manipulation and attention conflict. One possibility could be to present another person's face instead of a blank screen on the TV set in the low self-focus conditions.

Another noteworthy point is that our previous studies have also analyzed the role of experienced emotional states elicited by the self-relevance and task difficulty manipulations (Gendolla & Richter, 2005, 2006a, 2006b). This may be regarded as an important issue, because it could be argued that these manipulations have elicited states like threat (Smith, Nealey, Kircher, & Limon, 1997; Smith, Ruiz, & Uchino, 2000), anxiety (Gramer & Saria, 2007; Schwerdtfeger, 2004) or anger (Bongard, Pfeiffer, al'Absi, Hodapp, & Linnenkemper, 1997), which have been shown to influence cardiovascular reactivity in the context of task performance. However, in our previous studies self-relevance had no significant effects on anger or anxiety and neither these states nor the additionally assessed emotions had significant relationships with cardiovascular reactivity during task performance. Given these findings, we did not measure emotional states in the present studies. However, we are convinced that also the present effects on SBP reactivity are not biased by emotional states elicited by the manipulations.

In summary, we interpret the present results as showing the cardiovascular reactivity effects of perhaps the most central variable referring to self-relevance—self-focused attention that induces a state of self-evaluation and thus augments the importance of success in achievement situations (Duval & Wicklund, 1972; Silvia & Duval, 2001a). It is of note that the predictions that were tested and supported here are nonintuitive because previous research on self-focused attention and self-regulation has not considered the role of task difficulty for the intensity of motivation. Instead, researchers have connected self-focused attention to motivation by positing that self-focus induces a state of self-evaluation, which makes success important for the self (Duval & Wicklund, 1972; Wicklund, 1975; Wicklund & Duval, 1971). As a result, research has simply assumed that self-focused people will try harder, provided they expect to succeed (e.g., Carver et al., 1979; Duval, Duval, & Mulilis, 1992). Some experiments have measured physiological parameters after manipulating self-awareness but without any task to perform (e.g., Paulus, Annis, & Risner, 1978) or without manipulating task difficulty (Panayiotou & Vrana, 1998, 2004). Because past experiments did not vary task difficulty or manipulate more than two levels of expectations, it is hard to form a conclusive interpretation of their results in terms of the nonlinear effects predicted by the present approach. Thus, the present research is not only contributing to the evidence of self-relevant performance conditions' effects on resource mobilization (see Gendolla, 2004); it is also informative for some unresolved issues in the self-focus and self-regulation literature.

Footnotes

1As reported above, however, a preliminary analysis of gender effects had found that the a priori contrast significantly interacted with gender, $F(1,47)=4.68$, $p<.04$, $MSE=65.67$. Further analyses of this effect revealed that the a priori contrast was not significant for men ($p>.42$) but approached significance for women, $F(1,27)=3.10$, $p<.09$, $MSE=32.74$, with nonsignificant residuals for both tests ($Fs<1$). For women, DBP reactivity described the effort-related 3 versus 1 pattern. Reactivity in the high-self-focus/unfixed condition was relatively strong ($M=10.20$, $SE=2.22$), and weaker in the other conditions: low-self-focus/easy ($M=3.76$, $SE=1.92$), low-self-focus/unfixed ($M=8.21$, $SE=2.04$), high-self-focus/easy ($M=5.25$, $SE=2.07$). However, the high-self-focus/unfixed cell differed significantly only from the two low-self-focus/easy cells ($ps<.04$, two-tailed).

2An analysis of the response latencies revealed only a significant association ($r=.75$) between the response latencies during the practice trials and those during task performance, $F(1,51)=70.27$, $p<.001$, but no other effects ($ps>.13$). On average, participants needed 782.30 ms to respond ($SE=10.23$). This absence of differences in the latencies together suggests that the observed differences in committed errors were not due to differences in speed–accuracy trade-offs between the conditions.

3The analysis of the response latencies revealed no association between response latencies during the practice and performance periods ($p>.50$) and a highly significant difficulty main effect, $F(2,54)=88.80$, $p<.001$. All difficulty conditions differed significantly from one another (all $ps<.001$) due to faster reactions in the extreme condition ($M=255.89$ ms, $SE=4.75$) than the difficulty condition ($M=410.78$ ms, $SE=9.58$) and the unfixed condition ($M=650.28$, $SE=33.99$). No other effect approached significance ($ps>.50$).

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